Training and Validation of the Fast PCRTM_Solar Model

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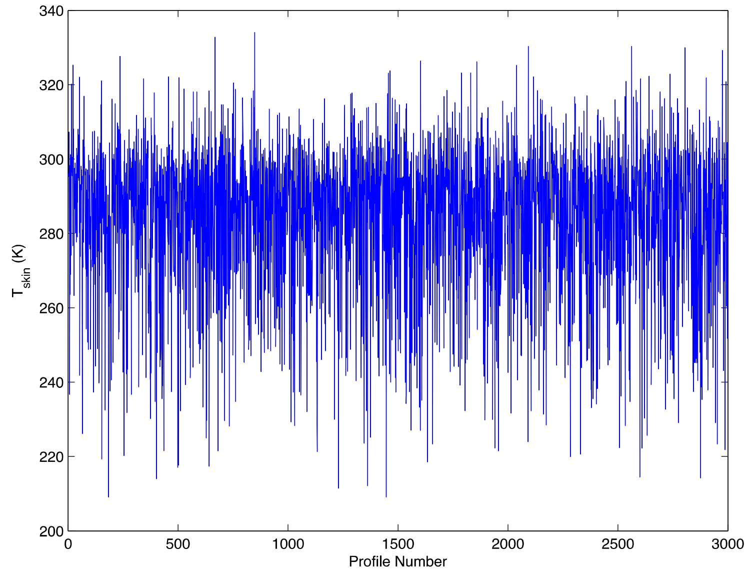
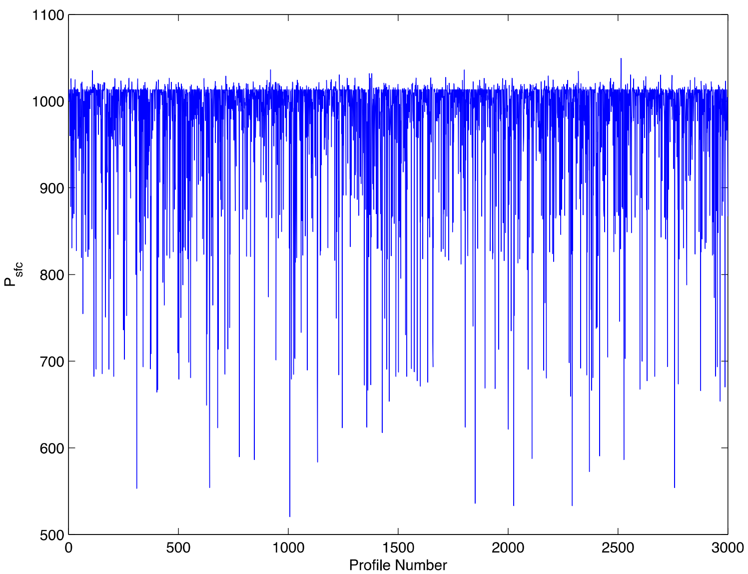
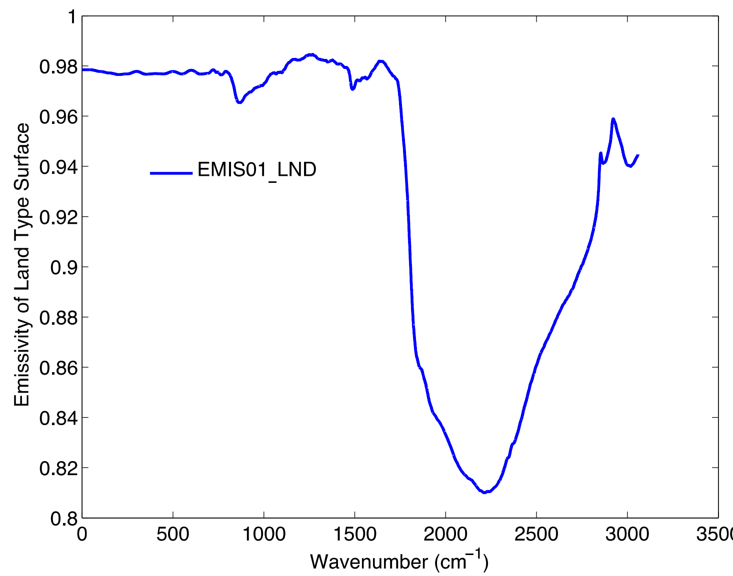
Motivation

- Extend the existing PCRTM to include solar reflection contribution.
- Generate robust cloud/aerosol LUTs for fast radiative transfer simulation.
- Training radiance data for IASI, NASTI, CrIS, AIRS, and SHIS instruments for PC based fast radiative transfer simulation.
- Apply the new results to retrieval applications.

Skin Temperature, Surface Pressure, and Surface Emissivity

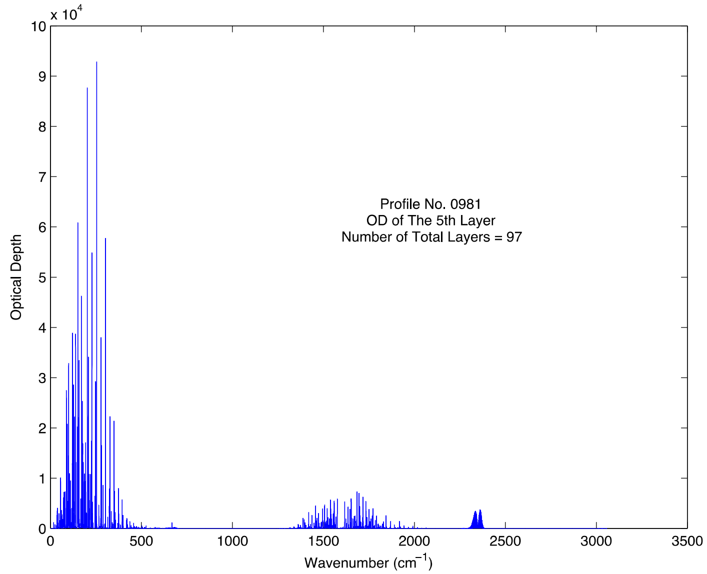


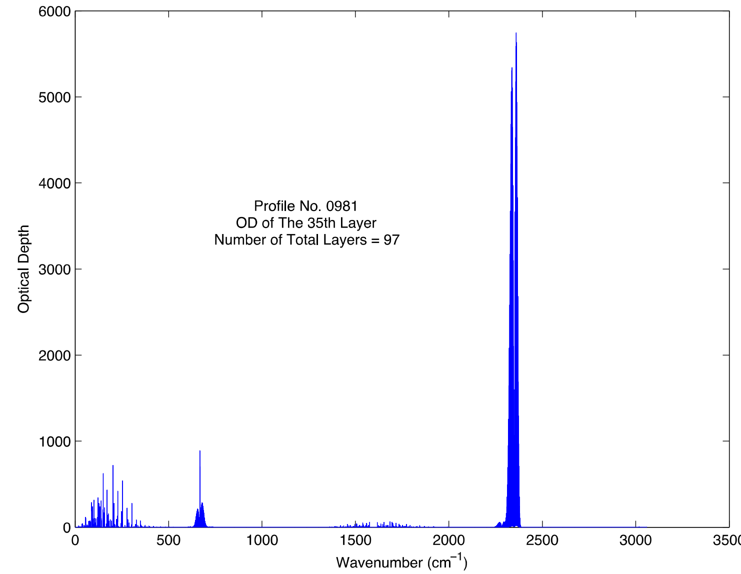


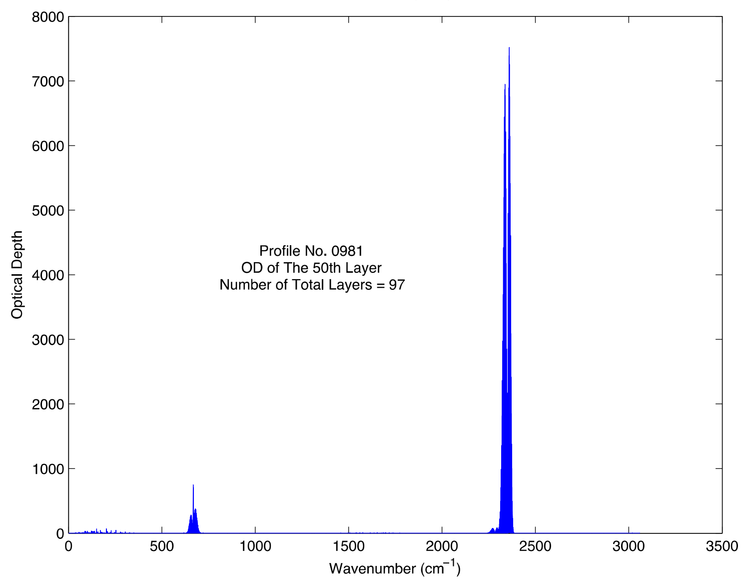


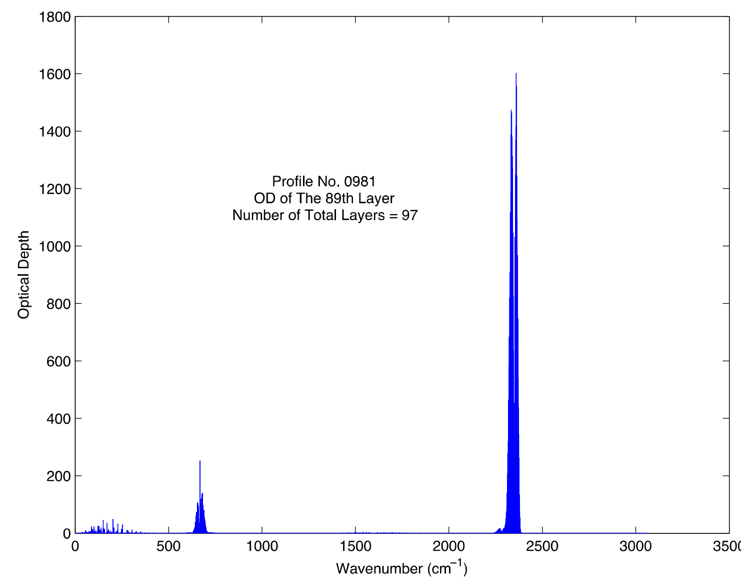
ART: 8	MIX: 185
OCN: 212	LND: 99

Typical OD of the Atmospheric Layers

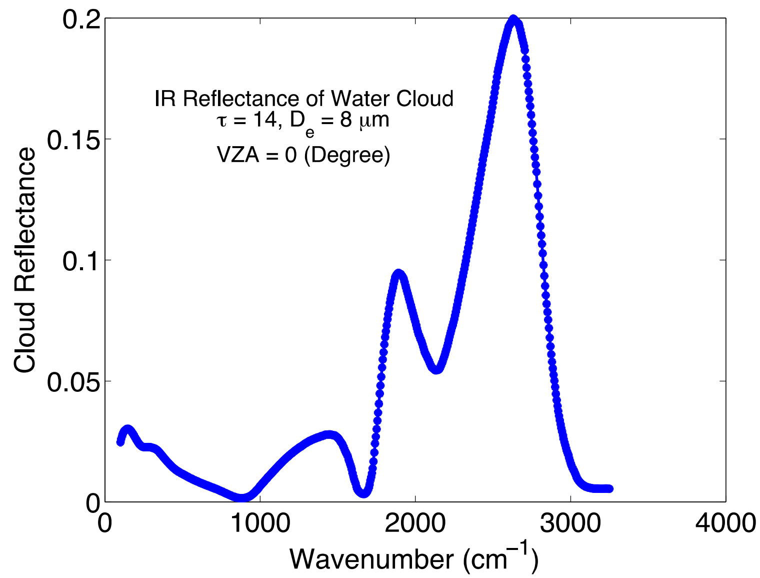


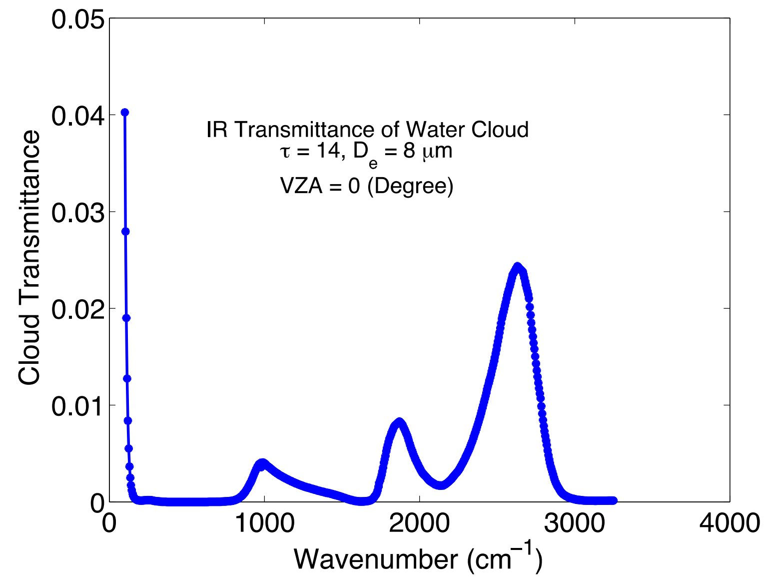


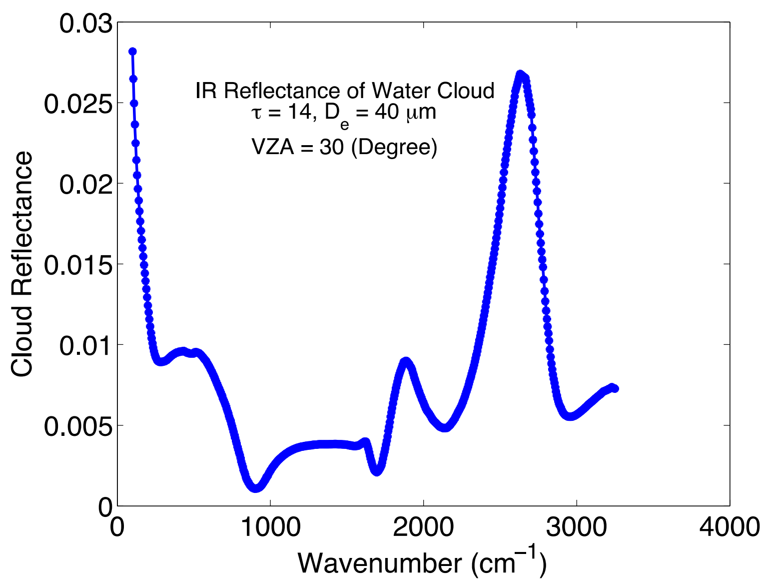


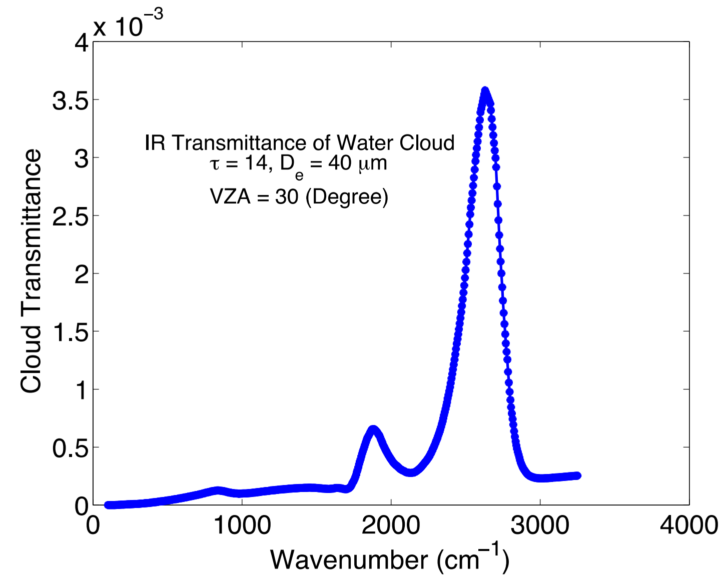


Typical Cloud Properties (Thermal)



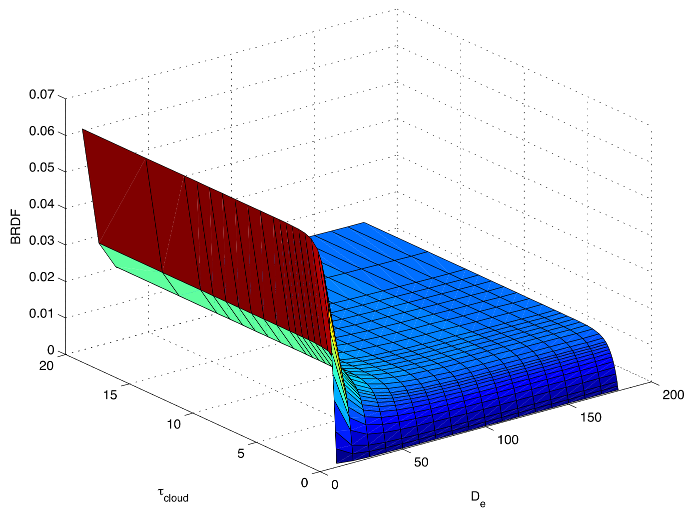


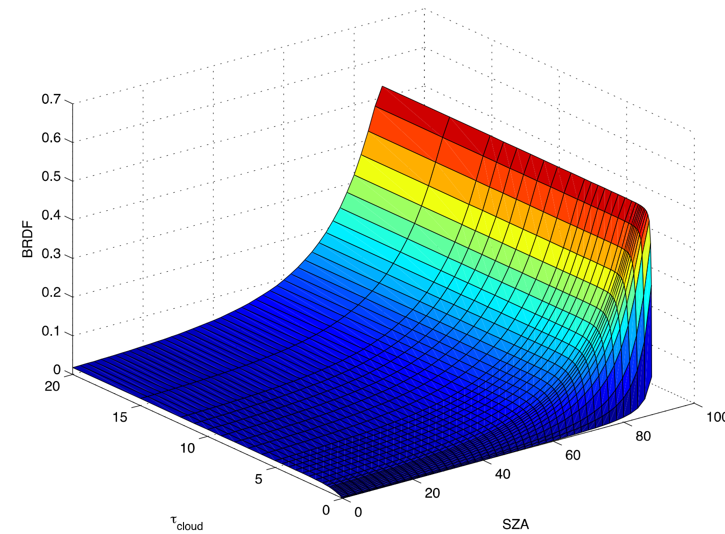


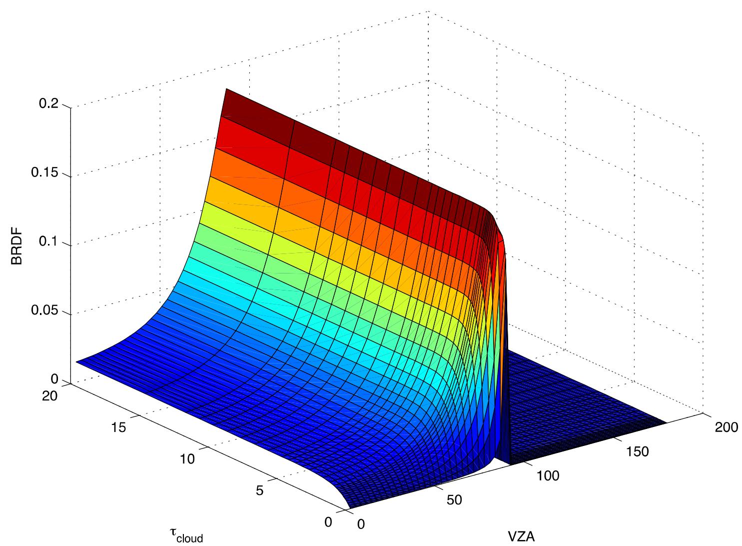


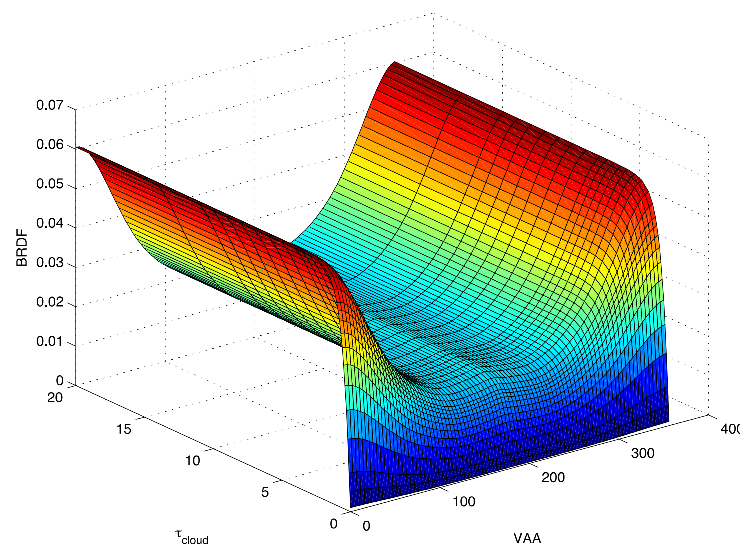
Typical Cloud Properties (Solar)

$$R_C = R(\tau, D_e, \mu_0, \mu, \phi - \phi_0, \lambda)$$

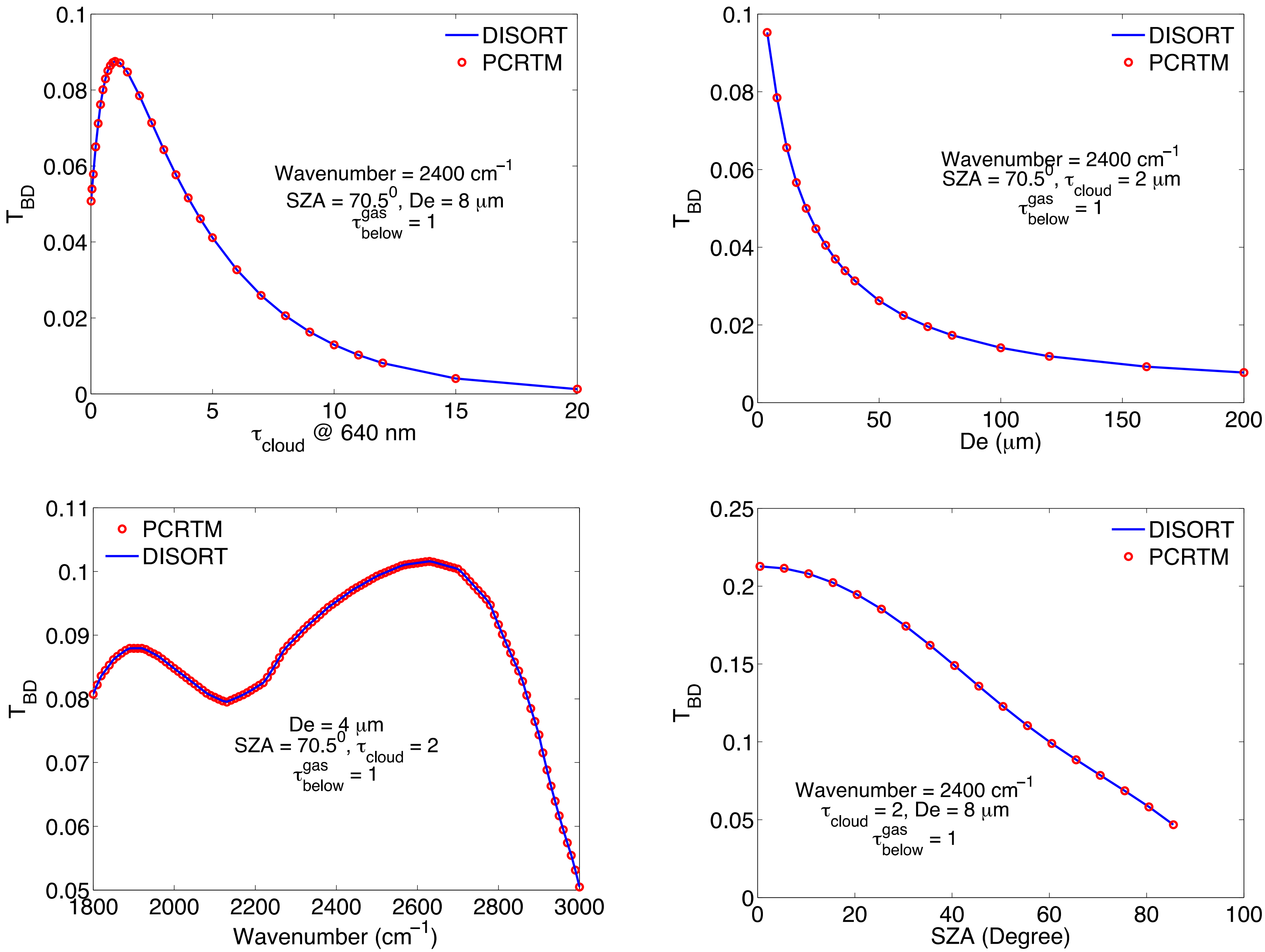




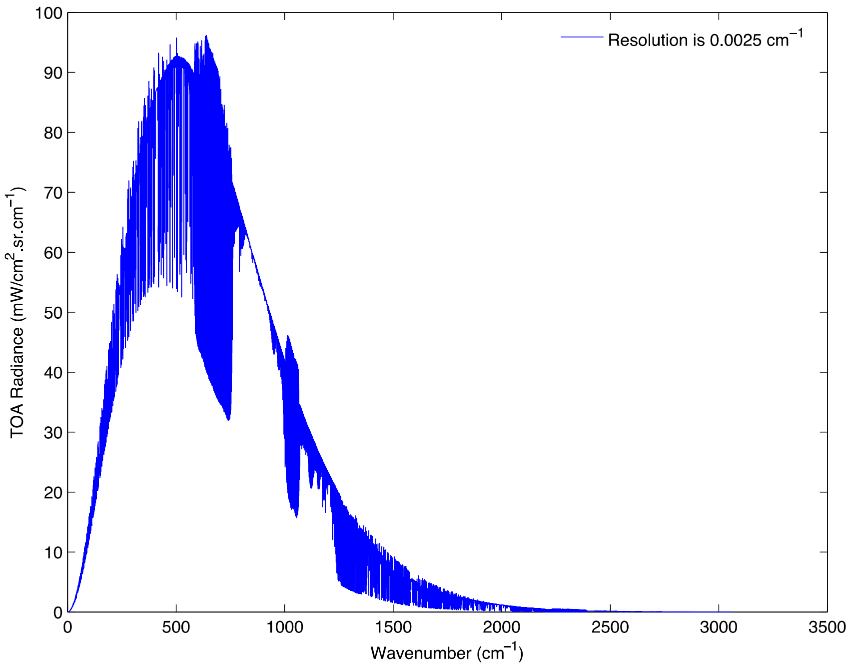


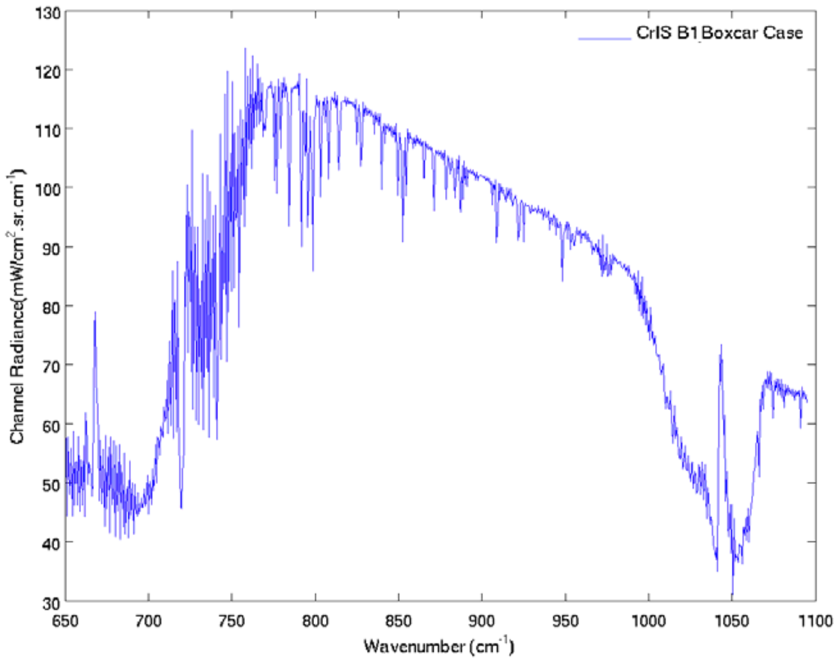


Typical Cloud Properties (Solar)



Typical TOA Radiance





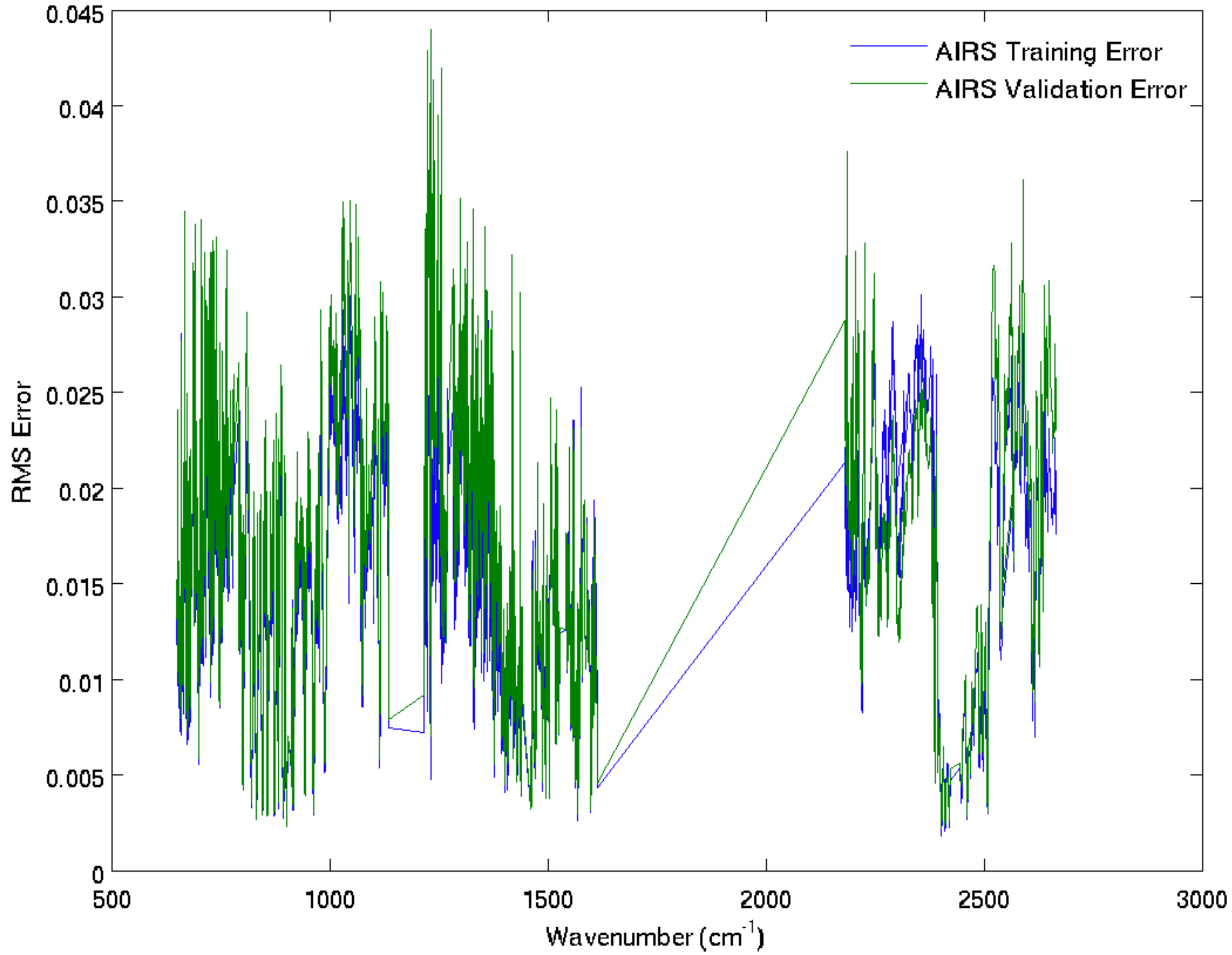
Mono radiance with very high resolution (0.0025 cm^{-1}) are need for RT simulation. The calculation of million mono radiances are very time consuming.

The channel radiances are obtained by convolving mono radiances with sensor response function:

$$R_i^{chan} = \sum_{k=1}^{N} \phi_k R_k^{mono}$$

Typical Training & Validation Errors

- AIRS as an Example



Training Result

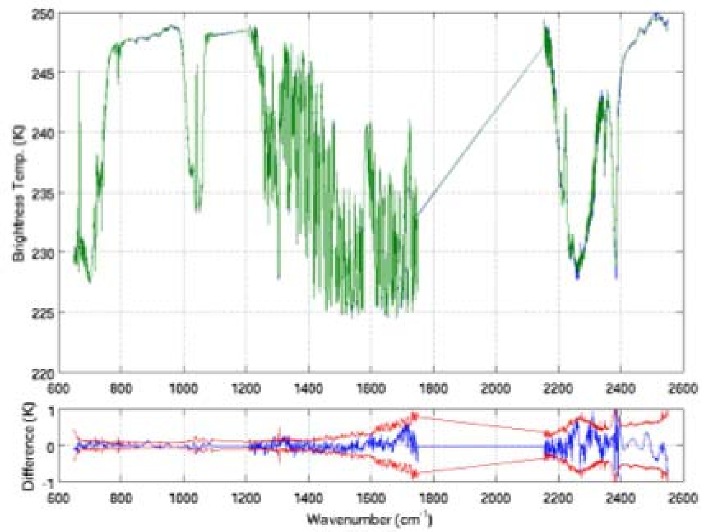
Instrument	Apodization	# of Channels	# of Mono	# of PC Score
IASI	Gaussian	2261+3160+3040	214+181+358	150+203+370
AIRS	Airs Filter	1262+602+514	206+108+186	119+84+129
HR CrIS	Boxcar	713+865+633	227+145+168	107+128+150
HR CrIS	Blackman	713+865+633	154+106+114	75+97+104
HR CrIS	Hamming	713+865+633	153+117+128	83+102+115
CrIS	Boxcar	717+437+163	224+123+138	110+96+89
CrIS	Blackman	717+437+163	159+97+113	76+67+60
CrIS	Hamming	717+437+163	176+98+110	84+72+64
NASTI	Boxcar	2718+2946+2968	232+214+302	222+216+488
NASTI	Kaiser	2718+2946+2968	192+152+215	171+177+334
SHIS	Boxcar	1359+1473+1484	208+136+303	158+181+320
SHIS	Kaiser	1359+1473+1484	208+136+303	120+109+305

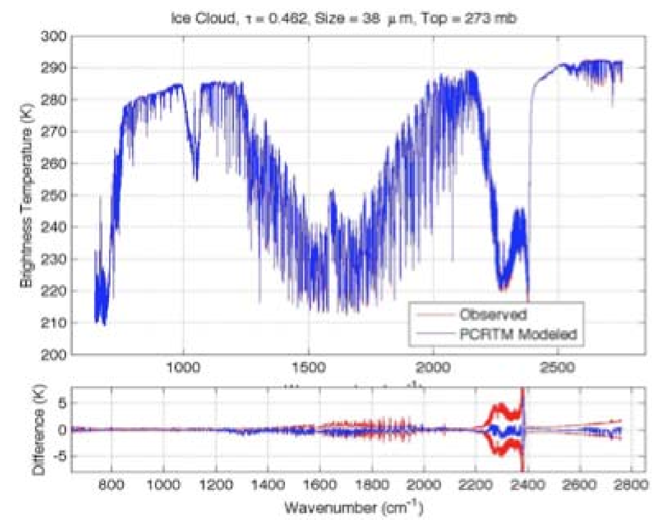
PCRTM Computational Speed Benchmark

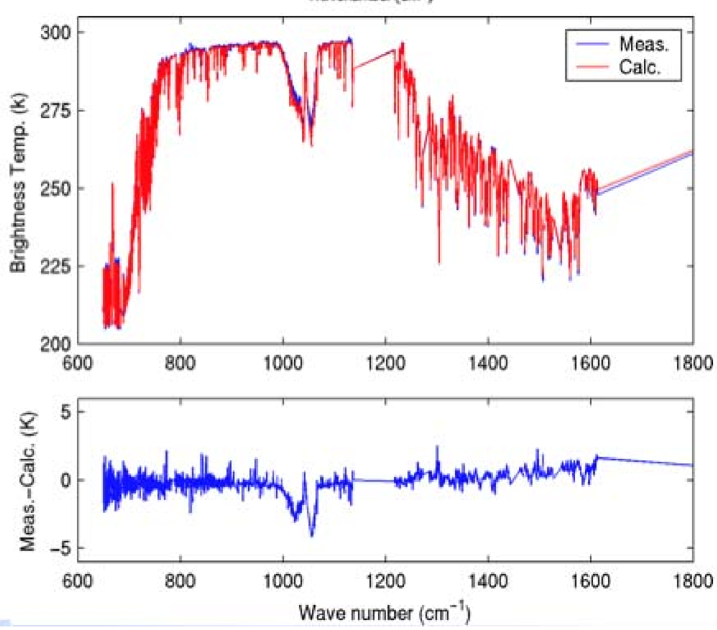
- A benchmark PCRTM computational speed has been performed
  - Intel(R) Quad core Q9550 CPU, 2.83GHz, Linux system
  - No parallelization performed

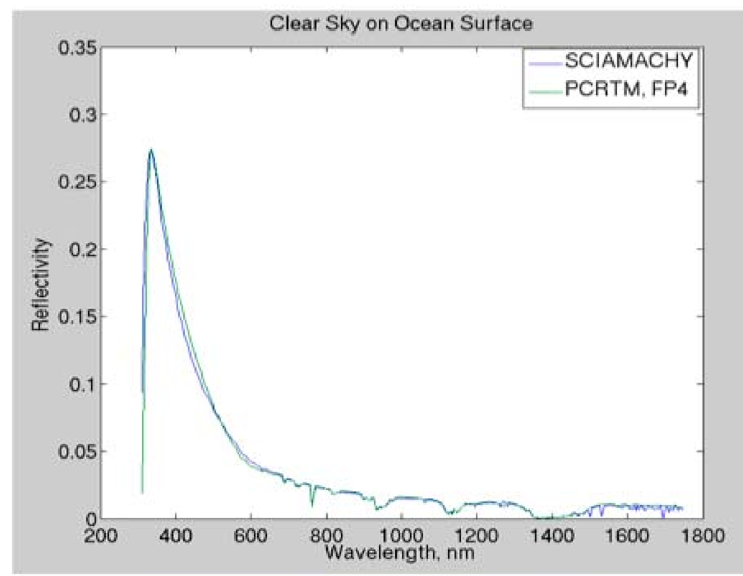
Sensor	Channel Number	PC score (seconds)	PC score + Channel radiance	PC score + PC Jacobian
CLARREO, 0.1 cm^{-1}	19901	0.014 s	0.022 s	0.052 s
CLARREO, 0.5 cm^{-1}	5421	0.011 s	0.013 s	0.039 s
CLARREO, 1.0 cm^{-1}	2711	0.0096 s	0.012 s	0.036 s
IASI, 0.25 cm^{-1}	8461	0.011 s	0.012 s	0.044 s
AIRS, 0.5-2.5 cm^{-1}	2378	0.0060 s	0.0074 s	0.031 s
CrIS, Blackman, 0.625-2.5 cm^{-1}	1317	0.0050 s	0.0060 s	0.021 s
CrIS, Boxcar, 0.625-2.5 cm^{-1}	1317	0.0050 s	0.0060 s	0.022 s
CrIS, Hamming, 0.625-2.5 cm^{-1}	1317	0.0050 s	0.0058 s	0.022 s
NAST-I, 3 bands, 0.25 cm^{-1}	8632	0.010 s	0.013 s	0.045 s
NAST-I, 44 bands, 0.25 cm^{-1}	8632	0.032 s	0.032 s	0.18 s

PCRTM Has Been Validation Using CrIS, IASI, AIRS, NASTI and SCIAMACHY Real Data









Conclusion

- In this work, we extended PCRTM to including the contribution from solar radiation, including the nonlocal thermal equilibrium (NLTE) effect.
- We used 1352 different atmosphere profiles, each of them has different surface skin temperatures and surface pressures in our training.
- Different surface emissivity spectra derived from ASTER database and emissivity models and some artificially generated emissivity spectra were used to account for diverse surface types of the earth.
- Concentrations of sixteen trace gases were varied systematically in the training and the remaining trace gas contributions were accounted for as a fixed gas.
- We have updated the PCRTM model for instruments such as IASI, NASTI, CrIS, AIRS, and SHIS. The training results show that the PCRTM model can calculate thousands of channel radiances by computing only a few hundreds of mono radiances. This greatly increased the computation efficiency since we do not need to calculate the millions of mono radiances and do the convolution process.
- The results from fast PCRTM_Solar simulation were compared to the instrument observed data. The simulated results were excellently agreed with the observations.